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(54) [Title of the Invention]

ELECTRIC-POWER SUPPLY UNIT

(57) ABSTRACT

[Objective]

[The objective of the present invention] is to provide an electric-power supply unit, which enables reduction in voltage stress and current stress applied on the inverter circuit and also enables miniaturization and cost reduction of the device, as well as enabling an improvement in the input power-factor, an improvement in the input current distortion and a suppression of the inrush current when the power is turned on.

[Means for the Resolution]

[The electric-power supply unit according to the present invention] is provided at least with a valley-infill power supply circuit 3, which includes a partial smoothing capacitor C1 and which infills [<sic> valley-infills] the valley part of the direct-current power output of a rectifier DB (which rectifies the alternating-current voltage source Vs), a capacitor C3 for cutting the

direct-current component, which cuts the direct-current component of the supply power to a load 4, and a series circuit of switching elements Q1 and Q2. It is [further] provided with an inverter circuit 2, which supplies high-frequency power to the load 4 by switching the switching elements Q1 and Q2 between ON and OFF alternately. The electric charge volume charged to said capacitor C3 for cutting the direct-current component is set approximately at zero during the period from the time at which the alternating-current voltage source Vs is turned on until the time at which the oscillation of said inverter circuit starts.

[CLAIMS]

[Claim 1] An electric-power supply unit being provided with:

A valley-infill power supply circuit that at least includes a partial smoothing capacitor and infills [<sic> valley-infills] the valley part of the direct current power output of a rectifier (which rectifies alternating voltage source),

A capacitor for cutting the direct-current component, which cuts the direct-current component of the supply power to a load, and

At least one switching element;
said electric-power supply unit being [further] provided with an inverter circuit, which supplies high-frequency power to said load through switching said switching element between ON and OFF [states];

Wherein the electric charge volume charged to said capacitor for cutting direct-current component is set approximately at zero during the period from the time at which the alternating-current power source is turned on until the time at which the oscillation of said inverter circuit starts.

[Claim 2] The electric-power supply unit according to Claim 1, wherein the means for setting, approximately at zero, the electric charge volume charged to said capacitor for cutting direct-current component comprises a switching element, and a diode connected in the reverse direction of the electric-charging direction of said partial smoothing capacitor, during the period from the time at

which the alternating-current voltage source is turned on until the time at which the oscillation of said inverter circuit starts.

[Claim 3] The electric-power supply unit according to Claim 2, characterized by being provided with a current-limiting constituent that limits the flow of the charging current of said partial smoothing capacitor.

[Claim 4] An electric-power supply unit, provided with:

A valley-infill power supply circuit, which at least includes a partial smoothing capacitor and infills [<sic> valley-infills] the valley part of the direct current power output of a rectifier (which rectifies alternating voltage source),

A capacitor for cutting the direct-current component, which cuts the direct-current component of the supply power to a load, and

At least one switching element;
said electric-power supply unit [further] provided with an inverter circuit, which supplies high-frequency power to said load by switching said switching element(s) between ON and OFF [states],

Wherein it is characterized by being provided with a current-limiting constituent that limits the flow of the charging current of said partial smoothing capacitor.

[Claim 5] The electric-power supply unit according to any one of the claims 1 through 4, characterized by being provided with a charge circuit for charging said partial smoothing capacitor up to a predetermined value during the period from the time at which the alternating-current voltage source is turned on until the time at which the oscillation of said inverter circuit starts.

[Claim 6] An electric-power supply unit, provided with:

A valley-infill power supply circuit, which at least includes a partial smoothing capacitor and infills [<sic> valley-infills] the valley part of the

direct current power output of a rectifier (which rectifies alternating voltage source),

A capacitor for cutting the direct-current component, which cuts the direct-current component of the supply power to a load, and

At least one switching element; said electric-power supply unit provided with an inverter circuit, which supplies high-frequency power to said load by switching said switching element(s) between ON and OFF [states],

Wherein it is characterized by being provided with a charge circuit for charging said partial smoothing capacitor up to a predetermined value during the period from the time at which the alternating-current power source is turned on until the time at which the oscillation of said inverter circuit starts.

[Claim 7] The electric-power supply unit according to any one of the claims 1 through 4, characterized by a current-limiting constituent being an impedance component.

[Claim 8] The electric-power supply unit according to any one of the claims 1 through 4, characterized by a current-limiting constituent being a thermistor.

[Claim 9] The electric-power supply unit according to Claim 5 or 6, wherein said charge circuit is configured to include a first capacitor having capacity smaller than that of said partial smoothing capacitor.

[Claim 10] The electric-power supply unit according to Claim 9 wherein the end-to-end voltage of said first capacitor serves as a control power source of a control circuit which controls said switching element.

[Claim 11] The electric-power supply unit according to Claim 9 or 10, characterized by being provided with an electric-discharging element for [discharging] the electric charge [that was] charged [in] said first capacitor.

[Claim 12] The electric-power supply unit according to Claim 11, characterized

by said electric-discharging element being an impedance component.

[Claim 13] The electric-power supply unit according to Claim 11, characterized by said electric-discharging element being a thermistor.

[Claim 14] The electric-power supply unit according to any one of the claims 1 through 6, characterized by said inverter circuit being configured to include a high-frequency-output feedback means that returns a portion of the high frequency output to the output terminal of said rectifier via said load.

[Claim 15] The electric-power supply unit according to any one of the claims 1 through 14, characterized by a load being formed that includes at least an electric-discharge lamp.

[Claim 16] The electric-power supply unit according to any one of the claims 1 through 14, characterized by said load being formed to include at least an electric-discharge lamp and a resonant circuit.

[Claim 17] The electric-power supply unit according to any one of the claims 1 through 16, characterized by said switching element being a bidirectional switching element.

[Claim 18] The electric-power supply unit according to any one of the claims 1 through 16, characterized by said switching element being a bidirectional switching element.

[Claim 19] The electric-power supply unit according to any one of the claims 1 through 16, characterized by said switching element having an anti-parallel connection diode.

[Claim 20] The electric-power supply unit according to any one of the claims 1 through 14, characterized by said inverter circuit being a half-bridge inverter circuit.

[Detailed Description of the Invention]
[0001]

[Field of Application of the Invention]
The present invention relates to an electric-power supply unit. More specifically, it relates to an electric-power supply unit that converts a direct-current output (which is obtained by rectifying an alternating-current voltage source) into an alternating-current power and supplies it to a load.

[0002]
[Conventional Technology]

(Conventional Example 1)
The first conventional example claimed by the present invention includes what is described in JP,59-220081,A. The schematic circuit diagram thereof is shown in Figure 19; and the waveform chart of the operation thereof is shown in Figure 20.
[0003] The present circuit is an electric-power supply unit that, in an inverter circuit 2, converts a direct-current output (which is obtained by rectifying an alternating-current voltage source Vs via a filter circuit F using a rectifier DB) into an alternating-current power, and supplies it to the load, namely, an electric-discharge lamp La.
[0004] Herein, the filter circuit F comprises an inductance element L3 connected to one end of the alternating-current voltage source Vs, and a (electrical) capacitor C5 connected in parallel to both ends of the alternating-current voltage source Vs via the inductance element L3. The inverter circuit 2 is a half-bridge inverter circuit comprising a series connection of switching elements Q1 and Q2, a capacitor C2 connected in parallel to both ends of the series connection of the switching elements Q1 and Q2, a series connection of a smoothing capacitor C1, an inductance element L1 and a diode D2 connected in parallel to both ends of the series connection of the switching elements Q1 and Q2, a diode D1 connected between the contact point of the switching elements Q1 ~ Q2, and the contact point of the diode D2 ~ the inductance element L1, and a series connection of an capacitor C3 for cutting the direct-current component and a load 4 connected between the contact point of the switching elements Q1 ~ Q2 and the positive output terminal of a rectifier DB; wherein the switching elements Q1 and Q2 cause high-frequency illumination of the electric-discharge lamp La (which is the load) by alternately repeating the switch between ON and OFF. It is to be noted that the switching elements Q1 and Q2 are controlled by a

control circuit 5. Also comprised [therein] is a valley-infill power supply circuit 3, which supplies a direct current voltage to the inverter circuit 2 from the switching elements Q1 and Q2, the inductance element L1, the partial smoothing capacitor C1, the diodes D1, D2. [Additionally,] the load 4 comprises a series connection of an inductance element L2 and a primary winding n1 of a transformer T connected between the positive output terminal of the partial smoothing capacitor C1 and the rectifier DB; a resonant capacitor (hereinafter referred to as the "capacitor") C4 connected in parallel to both ends of the primary winding n1 of the transformer T; and an electric-discharge lamp La connected in parallel to both ends of a secondary winding n2 of the transformer T. Further, a series connection comprising the inductance element L2, the primary winding n1 of the transformer T or the capacitor C4 configures a high-frequency-output feedback means that returns a portion of the high frequency output of the inverter circuit 2 to the output terminal of the rectifier DB.

[0005] The following is a brief explanation of the operation. First, the operation of the alternating-current voltage source Vs at the near-peak ($Vs \geqq Vc2$) is briefly described as follows:

[0006] When the switching element Q1 turns on and the switching element Q2 turns off, the input current flows via the route of the alternating-current voltage source Vs → filter circuit F → rectifier DB → switching element Q1 → diode D1 → inductance element L1 → partial smoothing capacitor C1 → rectifier DB → filter circuit F → alternating-current voltage source Vs, and meanwhile the resonance current flows via the route of the inductance element L2 → capacitor C4, the primary winding n1 of the transformer T → switching element Q1 → capacitor C3 for cutting the direct-current component → inductance element L2. When the switching element Q1 turns off and the switching element Q2 turns on, the regenerative current of the inductance element L1 flows via the route of the inductance element L1 → partial smoothing capacitor C1 → switching element Q2 → diode D1 → inductance element L1, and meanwhile the resonance current (namely, the regenerative current of the inductance element L2) flows via the route of the inductance element L2 → capacitor C4, the primary winding n1 of the transformer T → capacitor C2 → switching element Q2 → capacitor C3 for cutting the direct-current component → inductance element L2. In time, the direction of the resonance current flowing through the inductance element L2 is reversed, and [thereafter] [said resonance current] flows via the route of the

capacitor C2 → capacitor C4, the primary winding n1 of the transformer T → inductance element L2 → capacitor C3 for cutting the direct-current component → switching element Q2 → capacitor C2. And when the switching element Q1 turns on and the switching element Q2 turns off, the input current flows via the route of the alternating-current voltage source Vs → filter circuit F → rectifier DB → switching element Q1 → diode D1 → inductance element L1 → partial smoothing capacitor C1 → rectifier DB → filter circuit F → alternating-current voltage source Vs, and meanwhile the resonance current (namely, the regenerative current of the inductance element L2) flows via the route of the inductance element L2 → capacitor C3 for cutting the direct-current component → switching element Q1 → capacitor C4, the primary winding n1 of the transformer T → inductance element L2.

[0007] In this case, the capacitor C2 is charged from the alternating-current voltage source Vs, and therefore the waveform of the end-to-end voltage Vc2 of the capacitor C2, as shown in Figure 20 (a), comprises an approximately similar figure relative to the change of the alternating-current voltage source Vs. Additionally, an input current Iin having a waveform comprising an approximately similar figure relative to the change of the alternating-current voltage source Vs, such as that shown in Figure 20 (b), flows only when the switching element Q1 is in the ON [state] as described above; and an input current Iin having a wide conduction angle as shown in Figure 20 (b) is obtained by filtering the current thereof with the filter circuit F; thereby, it is possible to improve the input-power factor. The lamp current ILa, as shown in Figure 20 (c), comprises a high-frequency current waveform of an alternating current having an envelope curve with an approximately similar figure relative to the change of the end-to-end voltage Vc2 of the capacitor C2.

[0008] Operation of an alternating-current voltage source Vs at near-valley area (Vs ≦ Vc2) is briefly explained next. When the switching element Q1 turns on and the switching element Q2 turns off, the valley-infill current flows via the route of the partial smoothing capacitor C1 → inductance element L1 → diode D2 → capacitor C2 → partial smoothing capacitor C1, and meanwhile the resonance current flows via the route of the inductance element L2 → capacitor C4, the primary winding n1 of the transformer T → switching element Q1 → capacitor C3 for cutting the direct-current component → inductance element L2. When the switching element Q1 turns off and the switching element Q2 turns on, the valley-infill current flows via the route of the partial smoothing capacitor C1

→ inductance element L1 → diode D2 → capacitor C2 → partial smoothing capacitor C1, and meanwhile the resonance current (namely, the regenerative current of the inductance element L2) flows via the route of the inductance element L2 → capacitor C4, primary winding n1 of the transformer T → capacitor C2 → switching element Q2 → capacitor C3 for cutting the direct-current component → inductance element L2. In time, the direction of the resonance current flowing through the inductance element L2 is reversed, and [thereafter] [said resonance current] flows via the route of the capacitor C2 → capacitor C4, the primary winding n1 of the transformer T → inductance element L2 → capacitor C3 for cutting the direct-current component → switching element Q2 → capacitor C2. And when the switching element Q1 turns on and the switching element Q2 turns off, the valley-infill current flows via the route of the partial smoothing capacitor C1 → inductance element L1 → diode D2 → capacitor C2 → partial smoothing capacitor C1, and meanwhile the resonance current (namely, the regenerative current of the inductance element L2) flows via the route of the inductance element L2 → capacitor C3 for cutting the direct-current component → switching element Q1 → capacitor C4, the primary winding n1 of the transformer T → inductance element L2.

[0009] In this case, the capacitor C2 gradually discharges the electric charge to the partial smoothing capacitor C1 and the load 4; accordingly the waveform of the end-to-end voltage Vc2 of the capacitor C2 gradually decreases as shown in Figure 20 (a), while, as shown in Figure 20 (b), the input current Iin does not flow. The lamp current ILa, as shown in Figure 20 (c), comprises a high-frequency current waveform of an alternating current having an envelope curve with an approximately similar figure relative to the change of the end-to-end voltage Vc2 of the capacitor C2.

[0010] Meanwhile, as described above, the partial smoothing capacitor C1 is charged only when the switching element Q1 turns on, and an inductance element L1 is interposed in the electric-charging route of the partial smoothing capacitor C1. Accordingly, as shown in Figure 20 (a), the value of the end-to-end voltage Vc1 of the partial smoothing capacitor C1 becomes lower than that of the peak voltage [obtained from] rectifying the alternating-current voltage source Vs. Thus, the waveform of the end-to-end voltage Vc2 of the capacitor C2 comprises a voltage waveform having a ripple as shown in Figure 20 (a); and the waveform of the lamp current ILa also comprises a voltage waveform having a ripple that follows after the change of the end-to-end voltage Vc2 of the capacitor

C2 as shown in Figure 20 (c).

[0011] (Conventional Example 2)

The second conventional example claimed by the present invention includes that described in the Publication of the Japanese Patent Application No. (Tokugan) H06-291751. The schematic circuit diagram is shown in Figure 21, and the operation waveform chart is shown in Figure 22.

[0012] The difference from the first conventional example shown in Figure 19 is that a parallel circuit of a capacitor C6 and a diode D3 is interposed between the positive output terminal of rectifier DB and the high voltage side of the switching element Q1. The explanation of the other configurations identical to the first conventional example shall be omitted herein by affixing the identical reference coding therewith.

[0013] In the present circuit, because the current is supplied to an inverter circuit 2 from an alternating-current voltage source Vs according to the switching between ON and OFF of the switching elements Q1 and Q2, throughout the almost entire interval of one cycle of the alternating-current voltage source Vs, it becomes possible to cause the waveform of the input current Iin to form an approximate sine-wave shape as shown in Figure 22 (b); therefore it enables the input-power factor to be a high-power factor and makes it possible to improve the input-current waveform distortion, [thereby] making it possible to substantially reduce the harmonic content.

[0014] Meanwhile, in the case of the present conventional example, the resonance system of the inverter circuit 2 varies according to the size of the alternating-current voltage source Vs. At the near-peak of the alternating-current voltage source Vs, the resonance system comprises an inductance element L2, a capacitor C4, a primary winding n1 of the transformer T, and an electric-discharge lamp La. At the near-valley of the alternating-current voltage source Vs, the resonance system comprises an inductance element L2, a capacitor C4, a primary winding n1 of the transformer T, an electric-discharge lamp La, and a capacitor C6. Therefore, a lamp current ILa as shown in Figure 22 (c) approaches the maximum values respectively near the peak [point] and near the zero-cross [point] of the alternating-current voltage source Vs. In other words, the low frequency ripple of the output is substantially reduced by means of combining the resonant circuit in inverse proportion to the size of the end-to-end voltage Vc2 of the capacitor C2 and the

alternating-current voltage source Vs. Accordingly, the crest factor CF (= peak value/actual value) of the lamp current ILa is also improved, and along with it, the lamp-power factor is improved, [thereby] improving the luminous efficiency of the lamp as well.

[0015] It is to be noted that, in either one of the above-mentioned first and the second conventional examples, it becomes possible to suppress inrush current when turning the power on given that the charging current of the partial smoothing capacitor C1 does not flow unless either of the switching elements Q1 and Q2s turns on.

[0016]

[Objectives to Be Resolved by the Invention]

However, the above-mentioned first and the second conventional examples have problems (1) through (3) listed below.

[0017] (1) During the period from the time at which the power is turned on until the time at which the oscillation of the inverter circuit 2 starts, because there is no electric charging route present [for charging] to the large-capacity partial smoothing capacitor C1, the impedance of the entire circuit instantaneously becomes high, and the end-to-end voltage Vc2 of the overvoltage capacitor C2 (shown in Figure 23(b)), which was generated due to switch-surge that occurred when the power was turned on, ends up being impressed on the inverter circuit 2. In order to avoid this, high withstanding voltage electronic components and semiconductor elements, etc., are required, generating increases in the size of the device, the cost, etc.

[0018] (2) At the point when the power is turned on and the oscillation of the inverter circuit 2 starts, the partial smoothing capacitor C1 is charged when the switching element Q1 is ON. However, because the direct-current impedance value of the electric-charging route of the partial smoothing capacitor C1 remains [<sic> is] low until the end-to-end voltage Vc1 of the partial smoothing capacitor C1 reaches a steady-state voltage, a large current flows via the switching element Q1 and the diode D1, causing a large amount of stress to be applied upon the semiconductor element. In order to avoid this, high current-capacity semiconductor elements are required, generating increases in the size of the device, the cost, etc.

[0019] (3) During the period from the time at which the power is turned on until the time at which the oscillation of the inverter circuit 2 starts, the circuit shown

in Figure 19 comprises an equivalence of the circuit as shown in Figure 25. A partial smoothing capacitor C1 and a capacitor C3 for cutting the direct-current component may be used as the direct-current impedance elements in this equivalent circuit in the route of the alternating-current voltage source Vs → filter circuit F → rectifier DB → capacitor C4, primary winding n1 of the transformer T → inductance constituent L2 → capacitor C3 for cutting the direct-current component → diode D1 → inductance element L1 → partial smoothing capacitor C1 → rectifier DB → filter circuit F → alternating-current voltage source Vs. Nevertheless, because the capacity of the partial smoothing capacitor C1 is extremely large compared with the capacity of the capacitor C3 for cutting the direct-current component, most of the alternating-current voltage source Vs via the filter circuit F and the rectifier DB is impressed to the capacitor C3 for cutting the direct-current component. On the other hand, while it is in a steady state having the switching elements Q1 and Q2 oscillating with the duty ratio of 50%, the voltage (which is approximately half of the end-to-end voltage Vc2 of the capacitor C2) is impressed to the capacitor C3 for cutting the direct-current component at all times.

[0020] In other words, during the period from the time at which the power is turned on until the time at which the oscillation of the inverter circuit 2 starts, and during the period from the time at which the oscillation of the inverter circuit 2 starts until [it] reaches to the steady state, there is a large difference generated in the voltages Vc3 between both ends of the capacitor C3 for cutting the direct-current component. Thus, once the oscillation of the inverter circuit 2 starts, the excessive electric charge, which was charged by the capacitor C3 for cutting the direct-current component while the switching element Q1 was ON, is discharged; and therefore a large current I1 as shown in Figure 24 (b) flows via the route of the capacitor C3 for cutting the direct-current component → inductance element L2 → capacitor C4 and primary winding n1 of the transformer T → switching element Q1 → capacitor C3 for cutting the direct-current component such as shown in Figure 26, causing a large amount of stress to be applied upon the switching element Q1. In order to avoid this, high current-capacity semiconductor elements are required, generating the increases in the size of a device, the cost, etc.

[0021] The present invention was achieved in view of the above-mentioned problems; and the purpose thereof is to provide an electric-power supply unit that enables reduction in the voltage stress and the current stress applied on the

inverter circuit 2, miniaturization and cost reduction of the device, as well as improvement of the input power-factor, improvement of the input current distortion, the suppression of inrush current at the time of turning the power on.

[0022]

[Means for Resolving the Problems]

In order to resolve the above-mentioned problems, according to the invention of Claim 1, an electric-power supply unit is provided with a valley-infill power supply circuit that includes a partial smoothing capacitor at a minimum and also infills [<sic> valley-infills] the valley part of the direct-current power output of a rectifier (which rectifies the alternating-current voltage source), a capacitor for cutting the direct-current component, which cuts the direct-current component of the supply power to a load, and at least one switching element; said electric-power supply unit being provided [further] with an inverter circuit, which supplies high-frequency power to said load through switching said switching element between ON and OFF [states], wherein the electric charge volume charged to said capacitor for cutting the direct-current component is set approximately at zero during the period from the time at which the alternating-current voltage source is turned on until the time at which the oscillation of said inverter circuit starts.

[0023] According to the invention of Claim 2, the means for setting, approximately at zero, the electric charge volume charged to said capacitor for cutting the direct-current component is characterized by being provided with a switching element, and a diode connected in a reverse direction of the electric-charging direction of said partial smoothing capacitor, during the period from the time at which the alternating-current voltage source is turned on until the time at which the oscillation of said inverter circuit starts.

[0024] According to the invention of Claim 3, it is characterized by being provided with a current-limiting constituent that limits the flow of the charging current of the partial smoothing capacitor.

[0025] According to the invention of Claim 4, an electric-power supply unit is provided with a valley-infill power supply circuit, which at least includes a partial smoothing capacitor and infills [<sic> valley-infills] the valley part of the direct current power output of a rectifier (which rectifies alternating-current voltage source), a capacitor for cutting the direct-current component, which cuts the direct-current component of the supply power to a load, and at least one

switching element; said electric-power supply unit [further] provided with an inverter circuit, which supplies high-frequency power to said load by switching said switching element(s) between ON and OFF [states], wherein it is characterized by being provided with a current-limiting constituent that limits the flow of the charging current of the partial smoothing capacitor.

[0026] According to the invention of Claim 5, it is characterized by being provided with a charge circuit for charging said partial smoothing capacitor up to a predetermined value during the period from the time at which the alternating-current voltage source is turned on until the time at which the oscillation of said inverter circuit starts.

[0027] According to the invention of Claim 6, an electric-power supply unit is provided with a valley-infill power supply circuit, which at least includes a partial smoothing capacitor and infills [<sic> valley-infills] the valley part of the direct current power output of a rectifier (which rectifies alternating-current voltage source), a capacitor for cutting the direct-current component which cuts the direct-current component of the supply power to a load, and at least one switching element; said electric-power supply unit provided with an inverter circuit, which supplies high-frequency power to said load by switching said switching element(s) between ON and OFF [states], wherein it is characterized by being provided with a charge circuit for charging said partial smoothing capacitor up to a predetermined value during the period from the time at which the alternating-current voltage source is turned on until the time at which the oscillation of said inverter circuit starts.

[0028] According to the invention of Claim 7, it is characterized by a current-limiting constituent being an impedance component.

[0029] According to the invention of Claim 8, it is characterized by a current-limiting constituent being a thermistor.

[0030] According to the invention of Claim 9, the charge circuit is characterized by being formed by including a first capacitor having capacity smaller than that of said partial smoothing capacitor.

[0031] According to the invention of Claim 10, end-to-end voltage of the first capacitor is characterized by serving as a control power source of a control circuit that controls said switching element.

[0032] According to the invention of Claim 11, it is characterized by being provided with an electric-discharging element for [discharging] the electric charge [that was] charged [in] the first capacitor.

[0033] According to the invention of Claim 12, it is characterized by an electric-discharging element being an impedance component.
[0034] According to the invention of Claim 13, it is characterized by an electric-discharging element being a thermistor.
[0035] According to the invention of Claim 14, the inverter circuit is characterized by being configured including a high-frequency-output feedback means that returns a portion of the high frequency output to the output terminal of said rectifier via said load.
[0036] According to the invention of Claim 15, the load is characterized by being formed to include at least an electric-discharge lamp.
[0037] According to the invention of Claim 16, the load is characterized by being formed to include at least an electric-discharge lamp and a resonant circuit.
[0038] According to the invention of Claim 17, it is characterized by the switching element being a bidirectional switching element.
[0039] According to the invention of Claim 18, it is characterized by the switching element having a body diode.
[0040] According to the invention of Claim 19, it is characterized by the switching element having an anti-parallel connection diode.
[0041] According to the invention of Claim 20, it is characterized by the inverter circuit being a half-bridge inverter circuit.

[0042]
[Embodiment of the Invention]

(Embodiment 1)
The circuit diagram of the first embodiment claimed by the present invention is shown in Figure 1.
[0043] The difference from the first conventional example shown in Figure 19 is that it connects a diode D4 in anti-parallel to both ends of the series connection of an inductance element L1 and a partial smoothing capacitor C1, a diode D5 between an anode terminal of a diode D1 and the contact point of a switching element Q2 and a capacitor C3 for cutting the direct-current component, and a diode D6 in anti-parallel to both ends of the series connection of a switching element Q1 and a diode D5. The explanation of the other configurations identical to the first conventional example shall be omitted herein by affixing the identical reference coding therewith. It is to be noted that MOSFET is used

for the switching elements Q1 and Q2 in the present circuit.

[0044] Next, the operation is briefly explained in the following. When the switching element Q1 turns off and the switching element Q2 turns on, the resonance current flows via the route of the alternating-current voltage source Vs → filter circuit F → rectifier DB → capacitor C4, the primary winding n1 of the transformer T → inductance element L2 → capacitor C3 for cutting the direct-current component → Switching element Q2 → rectifier DB → filter circuit F → alternating-current voltage source Vs; and energy is stored in the inductance element L2. And when both switching elements Q1 and Q2 turn off, the energy stored in the inductance element L2 is discharged, and the resonance current flows via the route of the inductance element L2 → capacitor C3 for cutting the direct-current component → A diode D6 → capacitor C4 and primary winding n1 of the transformer T → inductance element L2. Subsequently, when the switching element Q1 turns on and the switching element Q2 turns off, the resonance current flows via the route of the capacitor C3 for cutting the direct-current component → inductance element L2 → capacitor C4, the primary winding n1 of the transformer T → Switching element Q1 → diode D5 → capacitor C3 for cutting the direct-current component, and energy is stored in the inductance element L2. Meanwhile, an input current flows only at the near-peak of the alternating-current voltage source Vs via the route of the alternating-current voltage source Vs → filter circuit F → rectifier DB → switching element Q1 → diode D1 → inductance element L1 → partial smoothing capacitor C1 → rectifier DB → filter circuit F → alternating-current voltage source Vs. And when both switching elements Q1 and Q2 turn off, the energy stored in the inductance element L2 is discharged, and the resonance current flows via the route of the inductance element L2 → capacitor C4, the primary winding n1 of the transformer T → capacitor C2 → body diode of the switching element Q2 (not shown) → capacitor C3 for cutting the direct-current component → inductance element L2.

[0045] In other words, because the switching elements Q1, Q2 and the diode D5 are turned off during the period from the time at which the power is turned on until the time at which the oscillation of the inverter circuit 2 starts, the capacitor C3 for cutting the direct-current component will not be charged with electric charge, nor will an overcurrent due to the capacitor C3 for cutting the direct-current component occur immediately after the oscillation of the inverter circuit 2 starts.

[0046]
(Embodiment 2)
The circuit diagram of the second embodiment claimed by the present invention is shown in Figure 2.
[0047] The difference from the first embodiment shown in Figure 1 is that the inverter circuit 2 has a load 4 provided at the low-voltage-side switching element Q2 side and is configured in the configuration equivalent to that of the inverter circuit 2 shown in Figure 1. The explanation of the other configurations identical to the first embodiment shall be omitted herein by affixing the identical reference coding therewith.
[0048] In other words, the inverter circuit 2 comprises a series connection of switching element Q1, diode D5, and [switching element] Q2; a capacitor C2 connected in parallel to both ends of the series connection of switching element Q1, diode D5, and switching element Q2; a series connection of diode D2, smoothing capacitor C1, and inductance element L1 connected in parallel to both ends of the series connection of switching element Q1, diode D5, and switching element Q2; a diode D1 connected between the contact point of the diode D5 ~ the switching element Q2 and the contact point of the partial smoothing capacitor C1 ~ the diode D2; a series connection of the capacitor C3 for cutting the direct-current component and load 4 connected between the contact point of the switching element Q1 ~ the diode D5 and the negative output terminal of the rectifier DB; a diode D4 connected in anti-parallel to both ends of the series connection of the inductance element L1 and the partial smoothing capacitor C1; and a diode D6 connected in anti-parallel to both ends of the switching element Q2 via the diode D5. Additionally, a valley-infill power supply circuit 3, which supplies direct current voltage to the inverter circuit 2 from the switching elements Q1 and Q2, the inductance element L1, the partial smoothing capacitor C1, the diodes D1, D2, and D4 ~ D6, is comprised [therein].

[0049]
(Embodiment 3)
The circuit diagram of the third embodiment claimed by the present invention is shown in Figure 3.
[0050] The difference from the first embodiment shown in Figure 1 is that a parallel circuit of the capacitor C6 and the diode D3 is interposed between the

positive output terminal of the rectifier DB and the high electric-potential side of the switching element Q1. The explanation of the other configurations identical to the first embodiment shall be omitted herein by affixing the identical reference coding therewith.
[0051] The difference from the second conventional example shown in Figure 21 is that the diode D4 is connected in anti-parallel to both ends of the series connection of the inductance element L1 and the partial smoothing capacitor C1; that the diode D5 is connected between the anode terminal of the diode D1 and the contact point of the switching element Q2 and the capacitor C3 for cutting the direct-current component; and that the diode D6 is connected in anti-parallel to both ends of the series connection of the switching element Q1 and the diode D5. The explanation of the other configurations identical to the second conventional example shall be omitted herein by affixing the identical reference coding therewith. It is to be noted that MOSFET is used for the switching elements Q1 and Q2 in the present circuit.
[0052] Next, the operation is briefly explained in the following. When the switching element Q1 turns off and the switching element Q2 turns on, the resonance current flows via the route of the capacitor C2 → capacitor C6 → capacitor C4, the primary winding n1 of the transformer T → inductance element L2 → capacitor C3 for cutting the direct-current component → Switching element Q2 → capacitor C2, in the event that the end-to-end voltage Vc2 of the capacitor C2 is larger than the total of the output voltage of the rectifier DB and the end-to-end voltage of the capacitor C6; the resonance current (= input current) flows via the route of the alternating-current voltage source Vs → filter circuit F → rectifier DB → capacitor C4, the primary winding n1 of the transformer T → inductance element L2 → capacitor C3 for cutting the direct-current component → switching element Q2 → rectifier DB → filter circuit F → alternating-current voltage source Vs, in the event that the end-to-end voltage Vc2 of the capacitor C2 is smaller than the total of the output voltage of the rectifier DB and the end-to-end voltage of the capacitor C6, [after which] the input current flows. Subsequently, when the switching element Q1 turns on and the switching element Q2 turns off, the resonance current flows via the route of the capacitor C3 for cutting the direct-current component → inductance element L2 → capacitor C4, the primary winding n1 of the transformer T → Capacitor C6 → switching element Q1 → diode D5 → capacitor C3 for cutting the direct-current component; and when the charging

electric-charge of the capacitor C6 is discharged while energy is stored in the inductance element L2 and [then] the charging electric-charge of the capacitor C6 is gone, the resonance current flows via the route of the capacitor C3 for cutting the direct-current component → inductance element L2 → capacitor C4, the primary winding n1 of the transformer T → Diode D3 → switching element Q1 → diode D5 → capacitor C3 for cutting the direct-current component. Additionally, in cases where only the near-peak of the alternating-current voltage source Vs (namely, the end-to-end voltage Vc2 of the capacitor C2) is smaller than the total of the output voltage of the rectifier DB and the end-to-end voltage of the capacitor C6, the input current flows via the route of the alternating-current voltage source Vs → filter circuit F → rectifier DB → capacitor C6, diode D3 → switching element Q1 → diode D1 → inductance element L1 → partial smoothing capacitor C1 → rectifier DB → filter circuit F → alternating-current voltage source Vs. And when both switching elements Q1 and Q2 turn off, the energy stored in the inductance element L2 is discharged, and the resonance current flows via the route of the inductance element L2 → capacitor C4, the primary winding n1 of the transformer T → capacitor C6, diode D3 → capacitor C2 → body diode of the switching element Q2 (not shown) → capacitor C3 for cutting the direct-current component → inductance element L2.
[0053] In other words, because the switching elements Q1 and Q2 and the diode D5 are turned off during the period from the time at which the power is turned on until the time at which the oscillation of the inverter circuit 2 starts, the capacitor C3 for cutting the direct-current component will not be charged with electric charge, nor will an overcurrent due to the capacitor C3 for cutting the direct-current component occur immediately after the oscillation of the inverter circuit 2 starts.

[0054]
(Embodiment 4)
The circuit diagram of the fourth embodiment claimed by the present invention is shown in Figure 4.
[0055] The difference from the third embodiment shown in Figure 3 is that the inverter circuit 2 has a load 4 provided at the low-voltage-side switching element Q2 side and is configured in the configuration equivalent to that of the inverter circuit 2 shown in Figure 3. The explanation of the other configurations identical to the third embodiment shall be omitted herein by affixing the

identical reference coding therewith.

[0056] In other words, the inverter circuit 2 comprises a series connection of switching element Q1, diode D5, and [switching element] Q2; a capacitor C2 connected in parallel to both ends of the series connection of switching element Q1, diode D5, and switching element Q2; a series connection of diode D2, smoothing capacitor C1, and inductance element L1 connected in parallel to both ends of the series connection of switching element Q1, diode D5, and switching element Q2; a diode D1 connected between the contact point of the diode D5 ~ the switching element Q2 and the contact point of the partial smoothing capacitor C1 ~ the diode D2; a series connection of the capacitor C3 for cutting the direct-current component and the load 4 connected between the contact point of the switching element Q1 ~ the diode D5 and the negative output terminal of the rectifier DB; a diode D4 connected in anti-parallel to both ends of the series connection of the inductance element L1 and the partial smoothing capacitor C1; and a diode D6 connected in anti-parallel to both ends of the switching element Q2 via the diode D5. Additionally, a valley-infill power supply circuit 3, which supplies direct current voltage to the inverter circuit 2 from the switching elements Q1 and Q2, the inductance element L1, the partial smoothing capacitor C1, the diodes D1, D2, and D4 ~ D6, is comprised [therein].

[0057]

(Embodiment 5)

The circuit diagram of the fifth embodiment claimed by the present invention is shown in Figure 5.

[0058] The difference from the first embodiment shown in Figure 1 is that it omits the diodes D4-D6; that the connection of the diode D1 with the anode terminal and the cathode terminal is reversed; that the series circuit of the inductance element L1 and the partial smoothing capacitor C1 is connected in parallel to both ends of the switching element Q1 via the diode D1; that the diode D2 is connected in anti-parallel to both ends of the switching element Q2 via the diode D1; and that the diode D1 is used as a substitute for a diode for preventing electric charging of the capacitor C3 for cutting the direct-current component (hereinafter referred to as the "diode") D5 prior to the start of oscillation of the inverter circuit 2 shown in Figure 1. The explanation of the other configurations identical to the first embodiment shall be omitted herein by affixing the identical reference coding therewith.

[0059]

(Embodiment 6)

The circuit diagram of the sixth embodiment claimed by the present invention is shown in Figure 6.

[0060] The difference from the fifth embodiment shown in Figure 5 is that the inverter circuit 2 has a load 4 provided at the low-voltage-side switching element Q2 side and is configured in the configuration equivalent to that of the inverter circuit 2 shown in Figure 5. The explanation of the other configurations identical to the fifth embodiment shall be omitted herein by affixing the identical reference coding therewith.

[0061] In other words, the inverter circuit 2 comprises a series connection of switching elements Q1 and Q2; a capacitor C2 connected in parallel to both ends of the series connection of the switching elements Q1 and Q2; a series connection of the smoothing capacitor C1, the inductance element L1, and the diode D2 connected in parallel to both ends of the series connection of the switching elements Q1 and Q2; a diode D1 connected between the contact point of the switching elements Q1 ~ Q2, and the contact point of the diode D2 ~ the inductance element L1; and a series connection of the capacitor C3 for cutting the direct-current component and the load 4 connected between the contact point of the switching elements Q1 and Q2, and the negative output terminal of the rectifier DB. And, [additionally] comprised [therein] is a valley-infill power supply circuit 3, which supplies a direct current voltage to the inverter circuit 2 from the switching elements Q1 and Q2, the inductance element L1, the partial smoothing capacitor C1, the diodes D1, D2.

[0062]

(Embodiment 7)

The circuit diagram of the seventh embodiment claimed by the present invention is shown in Figure 7.

[0063] The difference from the fifth embodiment shown in Figure 5 is that a parallel circuit of the capacitor C6 and the diode D3 is interposed between the positive output terminal of rectifier DB and the high electric-potential side of the switching element Q2. The explanation of the other configurations identical to the fifth embodiment shall be omitted herein by affixing the identical reference coding therewith.

[0064]

(Embodiment 8)

The circuit diagram of the eighth embodiment claimed by the present invention is shown in Figure 8.

[0065] The difference from the sixth embodiment shown in Figure 6 is that a parallel circuit of the capacitor C6 and the diode D3 is interposed between the negative output terminal of rectifier DB and the lower-voltage side of the switching element Q2. The explanation of the other configurations identical to the sixth embodiment shall be omitted herein by affixing the identical reference coding therewith.

[0066] Having configured as shown in the above-mentioned first through eighth embodiments, the capacitor C3 for cutting the direct-current component will not be charged with an electric charge during the period from the time at which the power is turned on until the time at which the oscillation of the inverter circuit 2 starts, nor will an overcurrent due to the capacitor C3 for cutting the direct-current component occur immediately after the oscillation of the inverter circuit 2 starts. Thus, miniaturization and cost reduction of the device become possible. Additionally, it also becomes possible to expand the conduction angle of the input current, to improve the input power-factor, to improve the input current distortion and to reduce inrush current during steady normal operation.

[0067]

(Embodiment 9)

The circuit diagram of the ninth embodiment claimed by the present invention is shown in Figure 9.

[0068] The difference from the second embodiment shown in Figure 2 is that it omits the diode D5 and D6, and connects a resistor R1 between the anode terminal of the diode D1 and the anode terminals of the diode D4 to be uses as the constituent to limit the flow of the charging current of the partial smoothing capacitor C1. The explanation of the other configurations identical to the second embodiment shall be omitted herein by affixing the identical reference coding therewith.

[0069] In the present circuit, at the near-peak of the alternating-current voltage source Vs, when the switching element Q1 is off and the switching element Q2 is on, the charging current of the partial smoothing capacitor C1 flows via the

route of the alternating-current voltage source Vs → filter circuit F → rectifier DB → inductance element L1 → partial smoothing capacitor C1 → resistor R1 → Diode D1 → switching element Q2 → rectifier DB → filter circuit F → alternating-current voltage source Vs. However, because the flow will be limited by the resistor R1, [the present circuit] can prevent the overcurrent to the partial smoothing capacitor C1, the switching element Q2, etc., in the lead-up to when the end-to-end voltage Vc1 of the partial smoothing capacitor C1 reaches a steady-state voltage. It is to be noted that, although there will be a power loss by the resistor R1 during a steady normal operation, there will not be a large power loss at resistor R1 as the discharging current from the inductance element L1 is bypassed with the diode D4 without going through the resistor R1.

[0070]
(Embodiment 10)
The circuit diagram of the tenth embodiment claimed by the present invention is shown in Figure 10.
[0071] The difference from the ninth embodiment shown in Figure 9 is that a parallel circuit of the capacitor C6, diode D3 is interposed between the negative output terminal of rectifier DB and the lower-voltage side of the switching element Q2. The explanation of the other configurations identical to the ninth embodiment shall be omitted herein by affixing the identical reference coding therewith. In the present circuit, at the near-peak of the alternating-current voltage source Vs, when the switching element Q1 is off and the switching element Q2 is on, the charging current of the partial smoothing capacitor C1 flows via the route of the alternating-current voltage source Vs → filter circuit F → rectifier DB → inductance element L1 → partial smoothing capacitor C1 → resistor R1 → diode D1 → switching element Q2 → capacitor C6, diode D3 → Rectifier DB → filter circuit F → alternating-current voltage source Vs. However, because the flow will be limited by the resistor R1, [the present circuit] can prevent the overcurrent to the partial smoothing capacitor C1, the switching element Q2, etc., in the lead-up to when the end-to-end voltage Vc1 of the partial smoothing capacitor C1 reaches a steady-state voltage. It is to be noted that, although there will be a power loss by the resistor R1 during steady normal operation, there will not be a large power loss at resistor R1 as the discharging current from the inductance element L1 is bypassed with the diode D4 without going through the resistor R1.

[0073]

(Embodiment 11)

The circuit diagram of the eleventh embodiment claimed by the present invention is shown in Figure 11. The difference from the ninth embodiment shown in Figure 9 is having used Thermistor TR instead of the resistor R1. The explanation of the other configurations identical to the ninth embodiment shall be omitted herein by affixing the identical reference coding therewith. Here, the thermistor TR has a property in which the higher the temperature gets, the lower the impedance value becomes. For this reason, while it is possible to prevent an overcurrent to the partial smoothing capacitor C1, the switching element Q2, etc., in the lead-up to when the end-to-end voltage Vc1 of the partial smoothing capacitor C1 reaches a steady-state voltage, it also becomes possible to suppress the power loss at the thermistor TR at a low level during steady normal operation.

[0074]

(Embodiment 12)

The circuit diagram of the twelfth embodiment claimed by the present invention is shown in Figure 12.

[0075] The difference from the eleventh embodiment shown in Figure 11 is that the parallel circuit of the capacitor C6 and the diode D3 are interposed between the negative output terminal of rectifier DB and the lower-voltage side of the switching element Q2. The explanation of the other configurations identical to the eleventh embodiment shall be omitted herein by affixing the identical reference coding therewith.

[0076] Having configured as shown in the above-mentioned ninth through the twelfth embodiment, a large amount of stress can be prevented from being impressed upon the semiconductor element and the partial smoothing capacitor C1 in the lead-up to when the end-to-end voltage Vc1 of the partial smoothing capacitor C1 reaches a steady-state voltage, preventing performance degradation in the semiconductor element and the partial smoothing capacitor C1, as well as enabling an extended service life, which in turn makes is possible to miniaturize the size and reduce the cost of the device. Additionally, it also becomes possible to expand the conduction angle of the input current, to improve the input-power factor, to improve the input current distortion and to reduce

inrush current during steady normal operation.

[0077]

(Embodiment 13)

The circuit diagram of the thirteenth embodiment claimed by the present invention is shown in Figure 13.

[0078] The difference from the second embodiment shown in Figure 2 is that a resistor R1 is connected between the anode terminal of the diode D1 and the anode terminals of the diode D4 to be used as the constituent for limiting the flow of the charging current of the partial smoothing capacitor C1. The explanation of the other configurations identical to the second embodiment shall be omitted herein by affixing the identical reference coding therewith.

[0079]

(Embodiment 14)

The circuit diagram of the fourteenth embodiment claimed by the present invention is shown in Figure 14.

[0080] The difference from the thirteenth embodiment shown in Figure 13 is that a parallel circuit of the capacitor C6 and diode D3 is interposed between the negative output terminal of rectifier DB and the low electric-potential side of the switching element Q2. The explanation of the other configurations identical to the thirteenth embodiment shall be omitted herein by affixing the identical reference coding therewith.

[0081] Having configured as shown in the above-mentioned the thirteenth and the fourteenth embodiments, the capacitor C3 for cutting the direct-current component will not be charged with the electric charge during the period from the time at which the power is turned on until the time at which the oscillation of the inverter circuit 2 starts, nor will an overcurrent due to the capacitor C3 for cutting the direct-current component occur immediately after the oscillation of the inverter circuit 2 starts. Thus, miniaturization and cost reduction of the device become possible. Moreover, since the flow of the charging current of the partial smoothing capacitor C1 is limited by the resistor R1 at the near-peak of the alternating-current voltage source Vs. Thereby, a large amount of stress can be prevented from being impressed upon the semiconductor element and the partial smoothing capacitor C1 in the lead-up to when the end-to-end voltage Vc1 of the partial smoothing capacitor C1 reaches a steady-state voltage,

preventing the performance degradation the semiconductor element and the partial smoothing capacitor C1 as well as enabling an extended service life, which in turn makes is possible to miniaturize the size and reduce the cost of the device. Additionally, it also becomes possible to expand the conduction angle of the input current, to improve the input power-factor, to improve the input current distortion and to reduce inrush current, during steady normal operation. It is to be noted that a thermistor TR may be used instead of resistor R1.

[0082] **(Embodiment 15)**

The circuit diagram of the fifteenth embodiment claimed by the present invention is shown in Figure 15.

[0083] The difference from the second embodiment shown in Figure 2 is that it omits the diodes D4-D6; that a series circuit comprising a diode D7 and a first capacitor (hereinafter referred to as the "capacitor") C7 is connected in parallel to both ends of the diode D2; and that a resistor R2 is connected in paralleled to both ends of the capacitor C7. The explanation of the other configurations identical to the second embodiment shall be omitted herein by affixing the identical reference coding therewith.

[0084] **(Embodiment 16)**

The circuit diagram of the sixteenth embodiment claimed by the present invention is shown in Figure 16.

[0085] The difference from the fifteenth embodiment shown in Figure 15 is that the parallel circuit of the capacitor C6 and the diode D3 are interposed between the negative output terminal of rectifier DB and the lower-voltage side of the switching element Q2. The explanation of the other configurations identical to the fifteenth embodiment shall be omitted herein by affixing the identical reference coding therewith.

[0086]

(Embodiment 17)

The circuit diagram of the seventeenth embodiment claimed by the present invention is shown in Figure 17.

[0087] The difference from the fifteenth embodiment shown in Figure 15 is that a zener diode ZD1 is connected in parallels to both ends of the capacitor C7 instead of the resistor R2, and that the end-to-end voltage Vc7 of the capacitor

C7 clamped by the zener diode ZD1 is used for the control power source of the control circuit 5. The explanation of the other configurations identical to the fifteenth embodiment shall be omitted herein by affixing the identical reference coding therewith.

[0088]

(Embodiment 18)

The circuit diagram of the eighteenth embodiment claimed by the present invention is shown in Figure 18.

[0089] The difference from the seventeenth embodiment shown in Figure 17 is that the parallel circuit of the capacitor C6 and the diode D3 are interposed between the negative output terminal of rectifier DB and the lower-voltage side of the switching element Q2. The explanation of the other configurations identical to the fifteenth embodiment shall be omitted herein by affixing the identical reference coding therewith.

[0090] Having configured as shown in the above-mentioned fifteenth through the eighteenth embodiments, it becomes possible to secure a charge circuit to alternating-current voltage source Vs → filter circuit F → rectifier DB → inductance element L1 → partial smoothing capacitor C1 → Diode D7 → capacitor C7 → (capacitor C6, diode D3 →) rectifier DB → filter circuit F → alternating-current voltage source Vs and a large-capacity partial smoothing capacitor C1 during the period from the time at which the power is turned on until the time at which the oscillation of the inverter circuit 2 starts; and it also becomes possible to prevent the overvoltage Vc2 (shown in Figure 23(b)) generated due to switch-surge (which occurs when the power is turned on), etc., as shown in Figure 23 (a) from being impressed on the inverter circuit 2. Additionally, it also becomes possible to expand the conduction angle of the input current, to improve the input power-factor, to improve the input current distortion and to reduce inrush current, during steady normal operation.

[0091] It is to be noted that, by setting the capacity of the capacitor C7 extremely low in comparison with the capacity of the partial smoothing capacitor C1, the capacitor C7 can be fully charged with a short period of time between the time at which the power is turned on and the time at which the oscillation of the inverter circuit 2 starts, and thus the electric power loss at the capacitor C7 will become extremely small. Additionally, the resistor R2 is an electric discharging element for discharging the electric charge of the capacitor C7 (namely, an

electric discharging resistor); and a thermistor TR may be used instead of a resistor R2. The diode D7 [therein] is [an element] for preventing the backflow of the electric charge of the capacitor C7.

[0092] While the circuit diagrams shown in the above-mentioned ninth through the eighteenth embodiments [show configurations] composed in such a way that the load 4 is provided in parallel at both ends of the low-voltage-side switching element Q2, it may be configured such as having the load 4 being provided in parallel at both ends of the high-voltage side-switching element Q1 such as to make it equivalent to the circuit configuration, like this. Additionally, while a resistor or a thermistor is used as a current-limiting constituent for the charging current of the partial smoothing capacitor C1 and the discharging element for discharging the electric charge of the capacitor C7, other impedance components may be used [therein].

[0093] Further, all the above-mentioned embodiments may use bidirectional switching elements, instead of a MOSFET with a body diode, for the switching elements Q1 and Q2; may have an anti-parallel connection diode; and while a half-bridge circuit was used as the inverter circuit 2, it may be other circuit systems.

[0094]

[Effect of the Invention]

According to the invention described in the claims 1 and 2, the capacitor for cutting the direct-current component will not be charged with the electric charge during the period from the time at which the power is turned on until the time at which the oscillation of the inverter circuit starts, nor will the overcurrent due to the capacitor for cutting the direct-current component be caused immediately after the start of oscillation of the inverter circuit. Accordingly, [the invention described in the claims 1 and 2] allow miniaturization and cost reduction of the device, as well as expansion of the conduction angle of the input current, improvement of the input power-factor, improvement of the input current distortion and reduction of the inrush current during steady normal operation.

[0095] The inventions of the claims 3, 4 and 7 can provide an electric-power supply unit that can prevent a large stress from being impressed upon the semiconductor element and the partial smoothing capacitor in the lead-up to when the end-to-end voltage of the partial smoothing capacitor reaches the steady-state voltage; that can extend the service life by preventing performance

degradation of the semiconductor element and the partial smoothing capacitor; and that can allow miniaturization and reduction of the cost of the device as well as expanding the conduction angle of the input current, improving the input power-factor, improving the input current distortion and reducing the inrush current, during the steady normal operation.

[0096] The invention described in the claims 5 and 6 can provide an electric-power supply unit that can, during the period from the time at which the power is turned on until the time at which the oscillation of the inverter circuit starts, secure the electric charging route to the partial smoothing capacitor; that can prevent the overvoltage caused by the switch surge (which is caused when turning the power on) from being impressed on the inverter circuit; and that can allow the expansion of the conduction angle of the input current, improvement of the input power-factor, improvement of the input current distortion and reduction of the inrush current during steady normal operation.

[0097] The invention of Claim 8 can provide an electric-power supply unit that can prevent a large stress from being impressed upon the semiconductor element and the partial smoothing capacitor in the lead-up to when the end-to-end voltage of the partial smoothing capacitor reaches the steady-state voltage; that can extend the service life by preventing performance degradation of the semiconductor element and the partial smoothing capacitor, and that can allow miniaturization and reduction of the cost of the device as well as controlling the power loss at the thermistor at a low level, expanding the conduction angle of the input current, improving the input power-factor, improving the input current distortion and reducing the inrush current during steady normal operation.

[0098] The invention described in the claims 9 and 12 can provide an electric-power supply unit that can, during the period from the time at which the power is turned on until the time at which the oscillation of the inverter circuit starts, secure the electric charging route to the partial smoothing capacitor; that can prevent the overvoltage caused by the switch surge (which is caused when turning the power on) from being impressed on the inverter circuit; and that can allow the expansion of the conduction angle of the input current, improvement of the input power-factor, improvement of the input current distortion and reduction of the inrush current during steady normal operation.

[0099] In addition, by setting the capacity of the capacitor extremely low in comparison with the capacity of the partial smoothing capacitor, the capacitor

can be fully charged in a short period of time between the time at which the power is turned on and the time at which the oscillation of the inverter circuit starts, and thus the electric power loss at the capacitor will be maintained at an extremely small amount.

[0100] The invention of Claim 13 can provide an electric-power supply unit that can, during the period from the time at which the power is turned on until the time at which the oscillation of the inverter circuit starts, secure the electric charging route to the partial smoothing capacitor; that can prevent an overvoltage caused by the switch surge (which is caused when turning the power on) from being impressed on the inverter circuit; and that can allow controlling the power loss at the thermistor at a low level, expanding the conduction angle of the input current, improving the input power-factor, improving the input current distortion and reducing the inrush current, during the steady normal operation.

[0101] In addition, by setting the capacity of the capacitor extremely low in comparison with the capacity of the partial smoothing capacitor, the capacitor can be fully charged in a short period of time between the time at which the power is turned on and the time at which the oscillation of the inverter circuit starts, and thus the electric power loss at the capacitor will be maintained at an extremely small amount.

[0102] The invention described in the claims 14, and 17 through 20 can provide an electric-power supply unit that can allow miniaturization and reduction of the cost of the device as well as expanding the conduction angle of the input current, [thereby] improving the input power-factor, improving the input current distortion and reducing the inrush current, during the steady normal operation.

[0103] The invention described in the claims 15 and 16 can provide an electric-power supply unit that can allow miniaturization and reduction of the cost of the device as well as providing a stable illumination of an electric-discharge lamp.

[Brief Description of the Diagrams]

[Figure 1] is a circuit diagram showing the first embodiment claimed by the present invention.

[Figure 2] is a circuit diagram showing the second embodiment claimed by the present invention.

[Figure 3] is a circuit diagram showing the third embodiment claimed by the present invention.

[Figure 4] is a circuit diagram showing the fourth embodiment claimed by the present invention.

[Figure 5] is a circuit diagram showing the fifth embodiment claimed by the present invention.

[Figure 6] is a circuit diagram showing the sixth embodiment claimed by the present invention.

[Figure 7] is a circuit diagram showing the seventh embodiment claimed by the present invention.

[Figure 8] is a circuit diagram showing the eighth embodiment claimed by the present invention.

[Figure 9] is a circuit diagram showing the ninth embodiment claimed by the present invention.

[Figure 10] is a circuit diagram showing the tenth embodiment claimed by the present invention.

[Figure 11] is a circuit diagram showing the eleventh embodiment claimed by the present invention.

[Figure 12] is a circuit diagram showing the twelfth embodiment claimed by the present invention.

[Figure 13] is a circuit diagram showing the thirteenth embodiment claimed by the present invention.

[Figure 14] is a circuit diagram showing the fourteenth embodiment claimed by the present invention.

[Figure 15] is a circuit diagram showing the fifteenth embodiment claimed by the present invention.

[Figure 16] is a circuit diagram showing the sixteenth embodiment claimed by the present invention.

[Figure 17] is a circuit diagram showing the seventeenth embodiment claimed by the present invention.

[Figure 18] is a circuit diagram showing the eighteenth embodiment claimed by the present invention.

[Figure 19] is a circuit diagram showing the first conventional example claimed by the present invention.

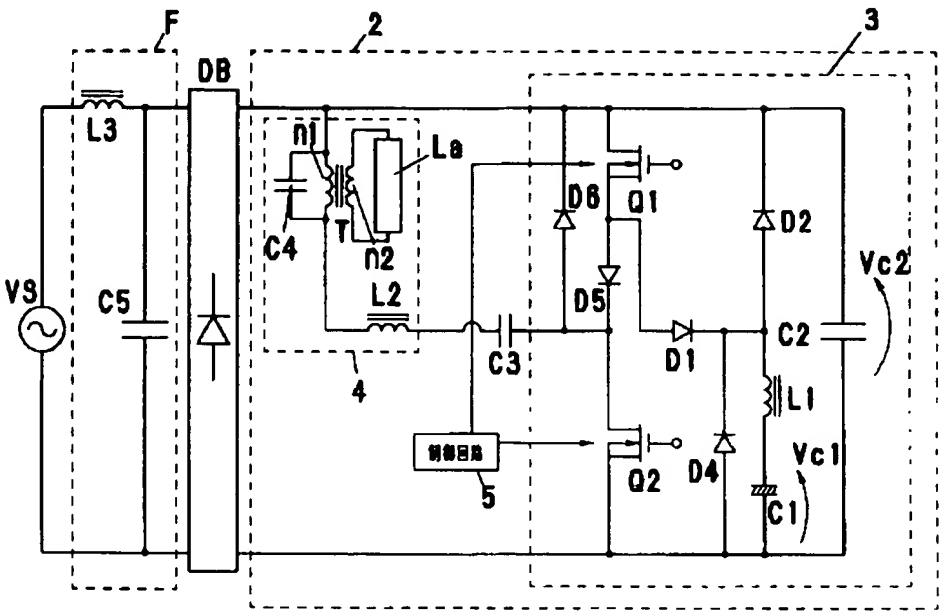
[Figure 20] is an operation waveform chart claimed by the above-mentioned conventional example.

[Figure 21] is a circuit diagram showing the second conventional example claimed by the present invention.
[Figure 22] is an operation waveform chart claimed by the above-mentioned conventional example.
[Figure 23] shows an operation waveform chart when the power is turned on, claimed by the above-mentioned first and the second conventional examples.
[Figure 24] shows another operation waveform chart claimed by the above-mentioned first and the second conventional examples.
[Figure 25] shows an equivalent circuit diagram during the period from the time at which the power is turned on until the time at which the oscillation of the inverter circuit starts, as claimed by the above-mentioned first and the second conventional examples.
[Figure 26] shows an equivalent circuit diagram depicting when the switching element Q1 is in the ON [state], as claimed by the above-mentioned first and the second conventional examples.

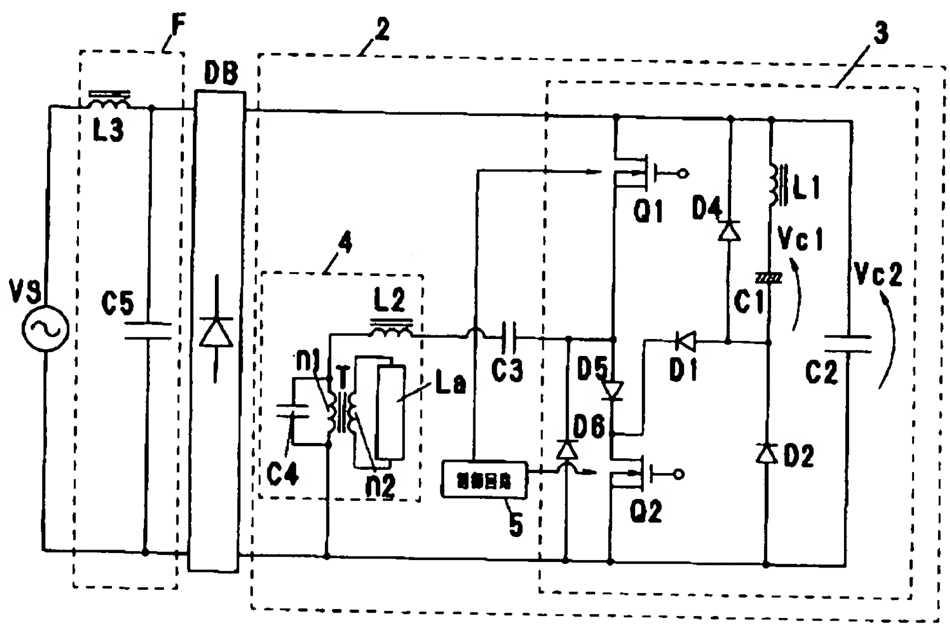
[Description of Reference Coding]

C	Capacitor
D	Diode
DB	Rectifier
La	Electric-discharge lamp
Q	Switching element
R	Resistor
TR	Thermistor
Vs	Alternating voltage source
2	Inverter circuit
3	Valley-infill power supply circuit
4	Load
5	Control circuit

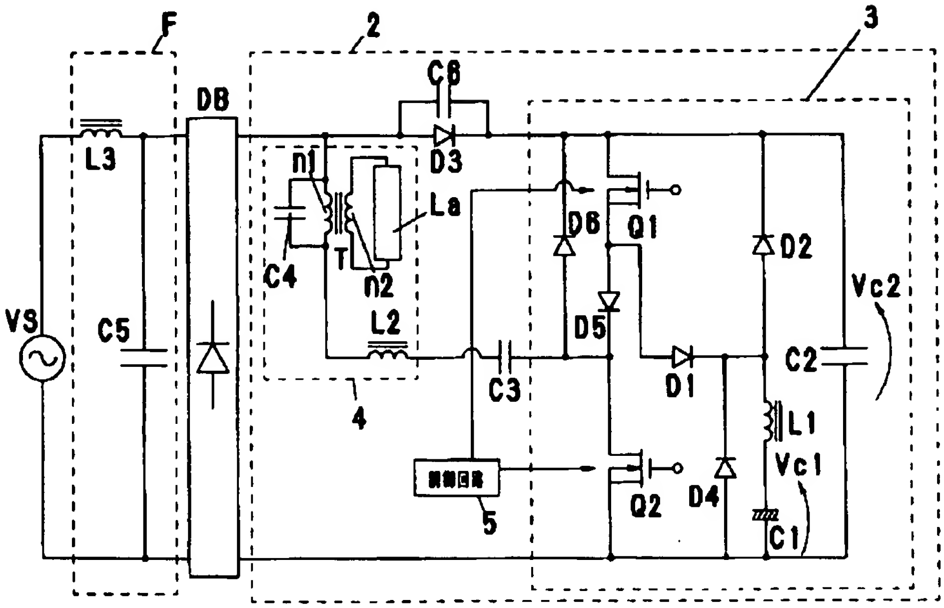
【Figure 1】



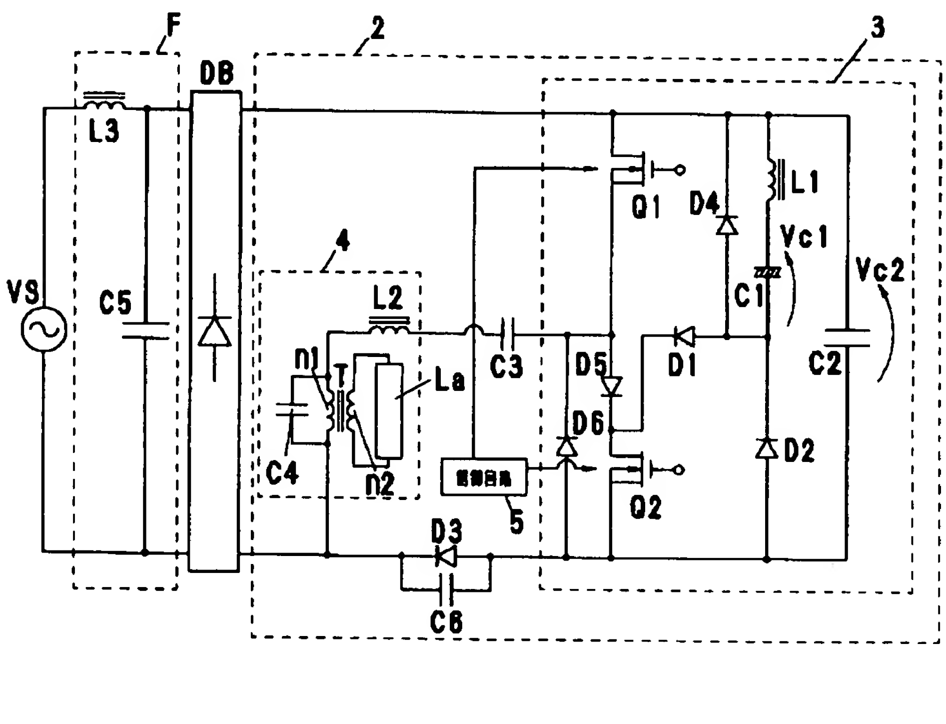
【Figure 2】



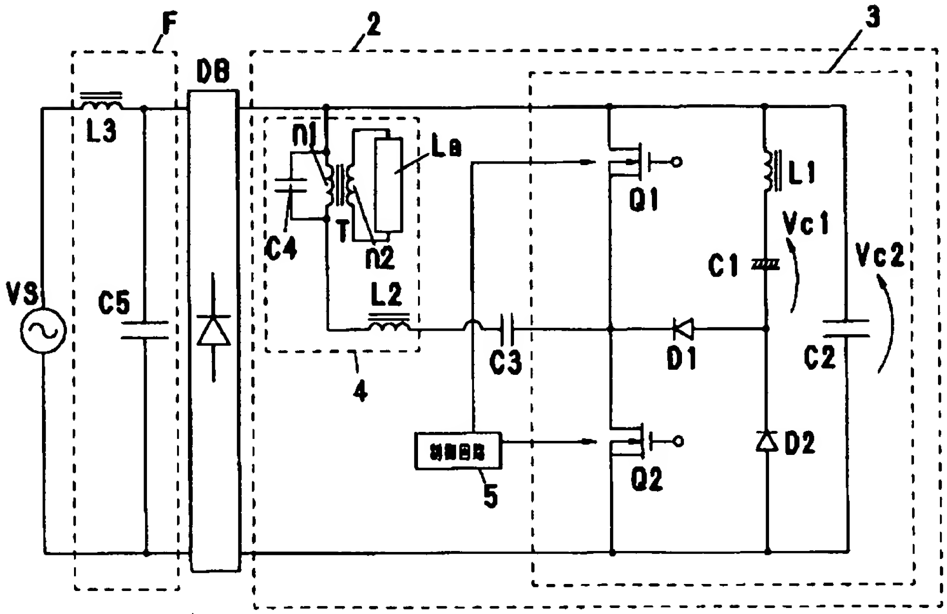
【Figure 3】



【Figure 4】



【Figure 5】



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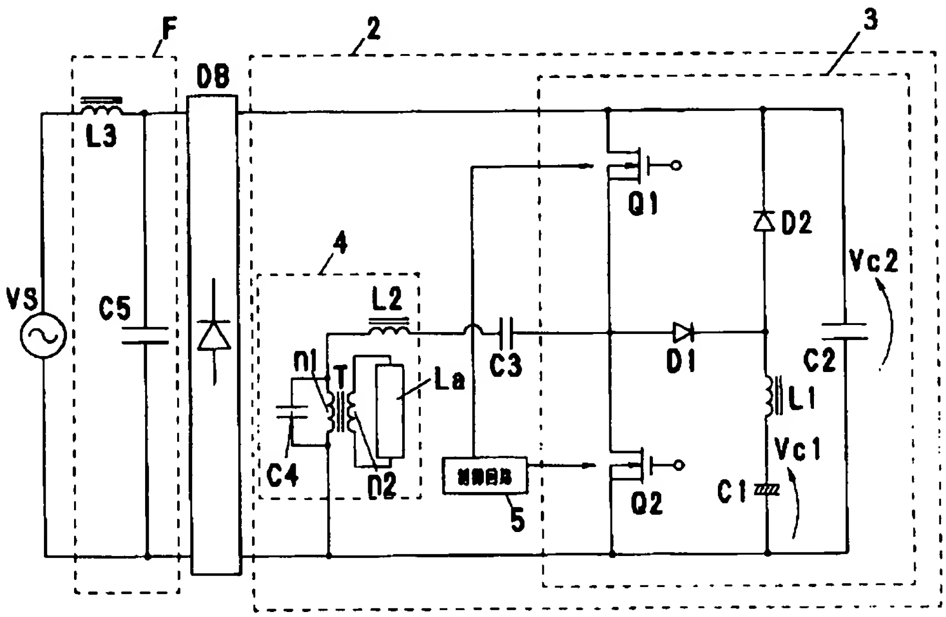

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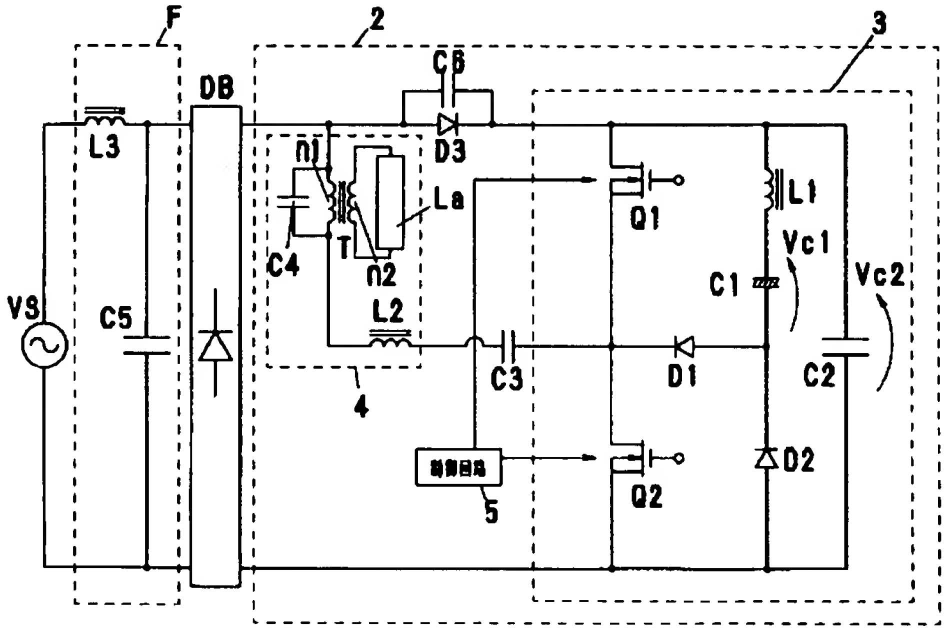

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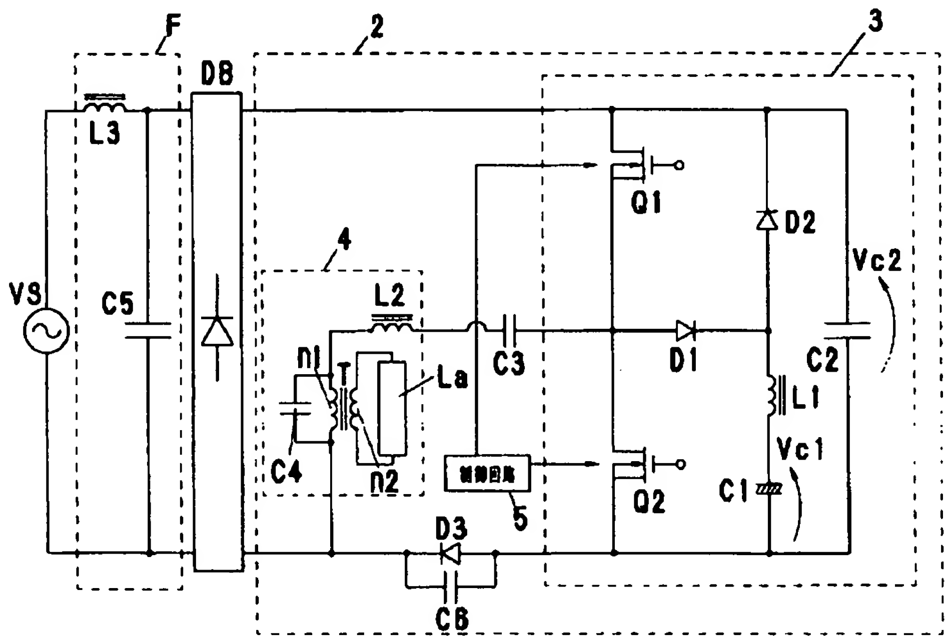
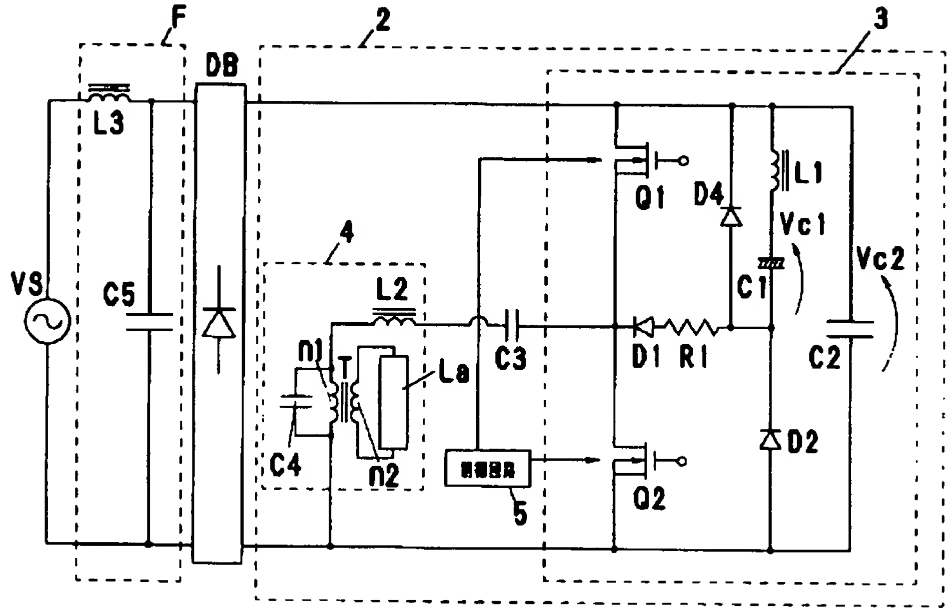
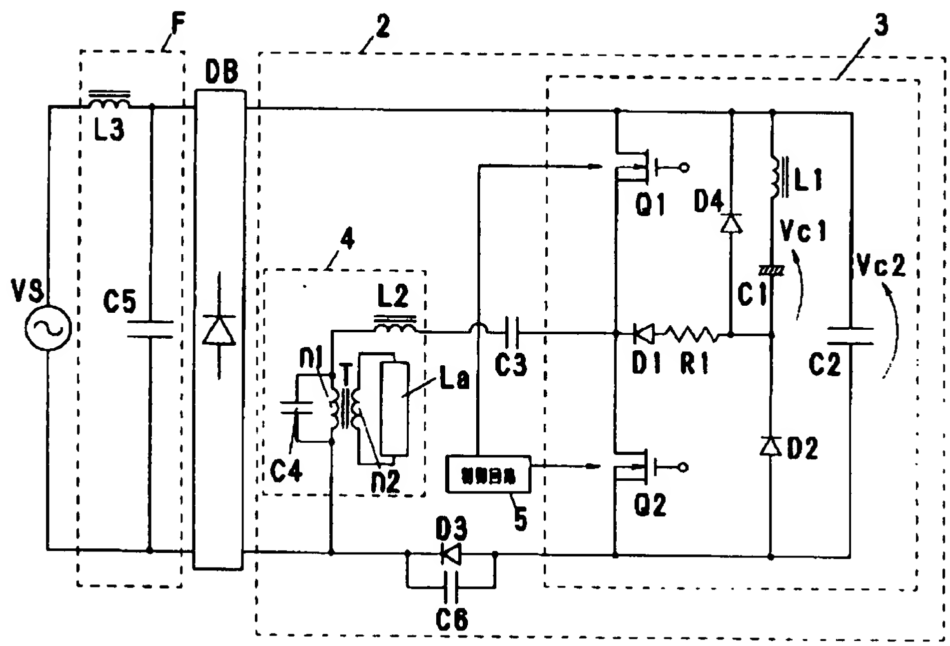


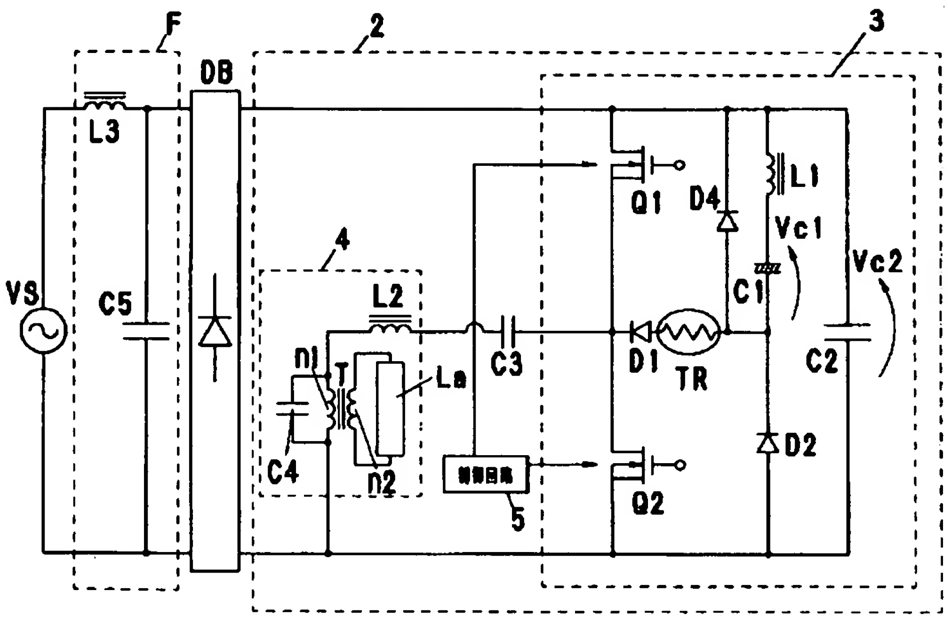
【Figure 9】



【Figure 10】



【Figure 1 1】



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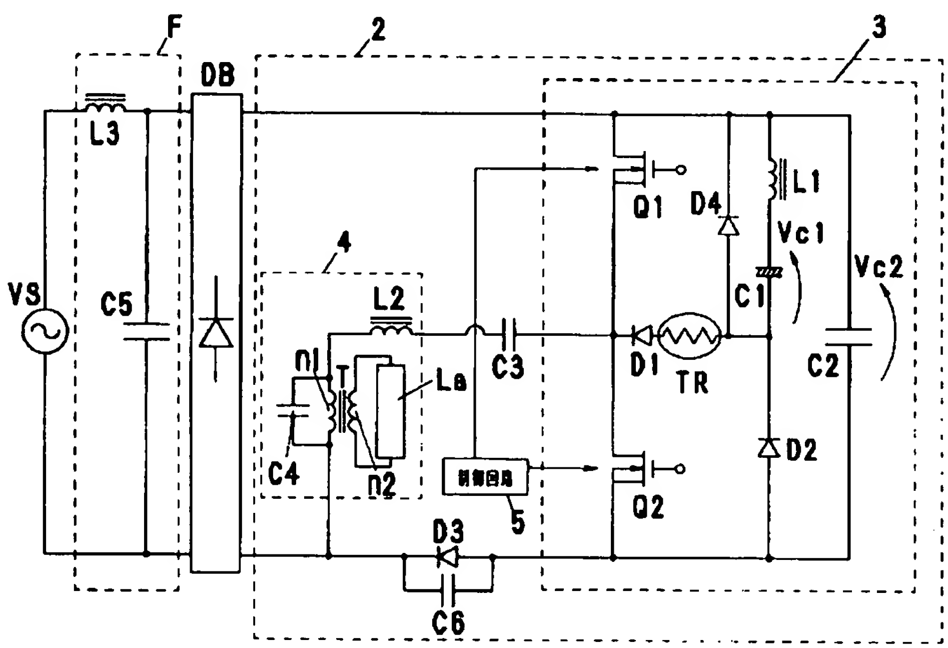

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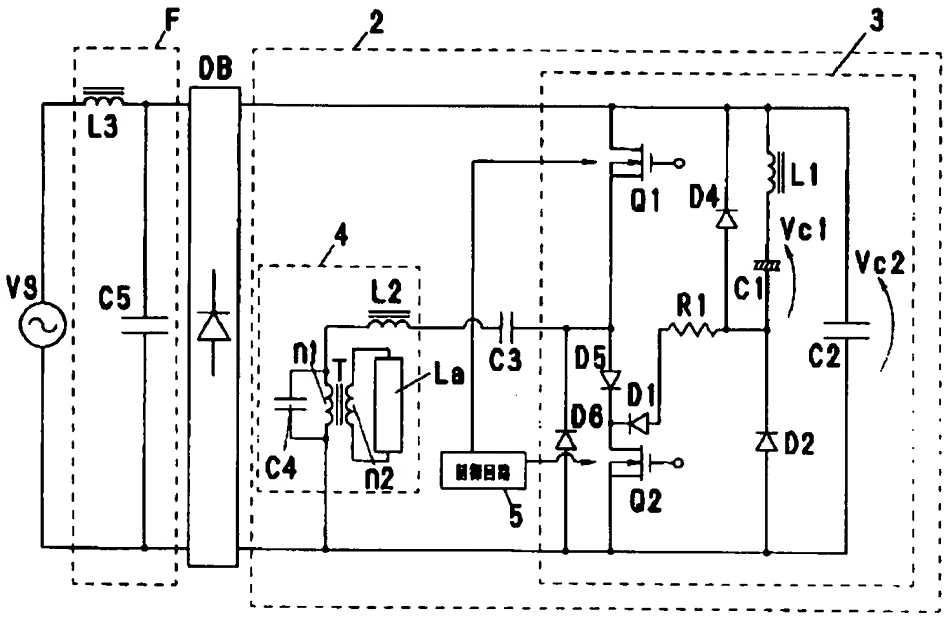
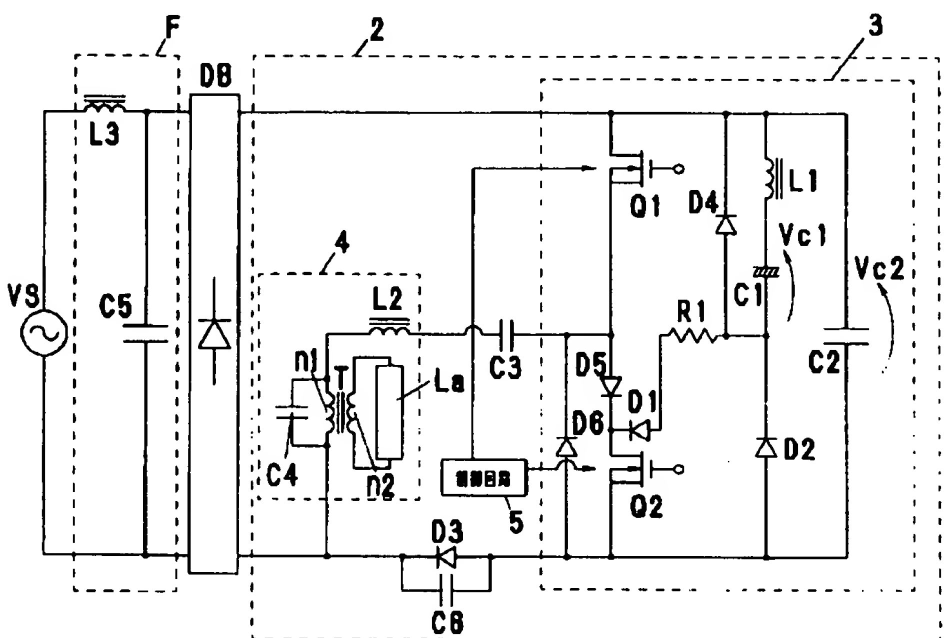
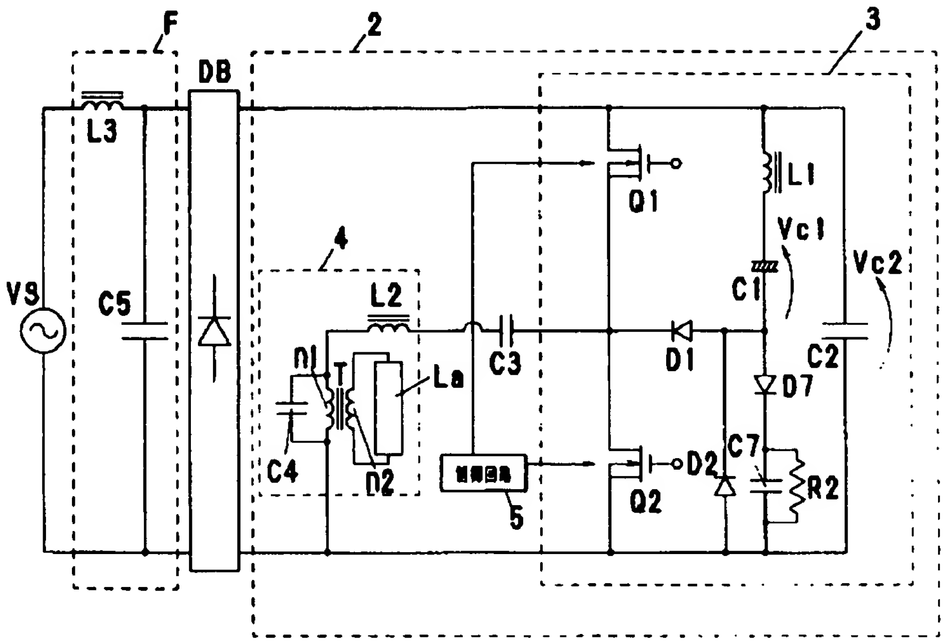


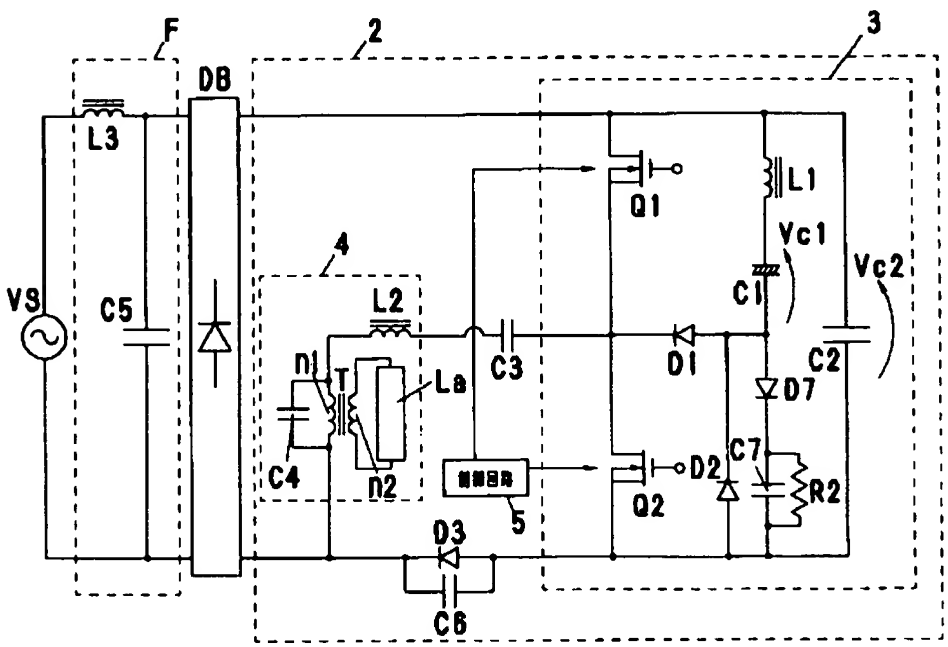
【Figure 1 4】



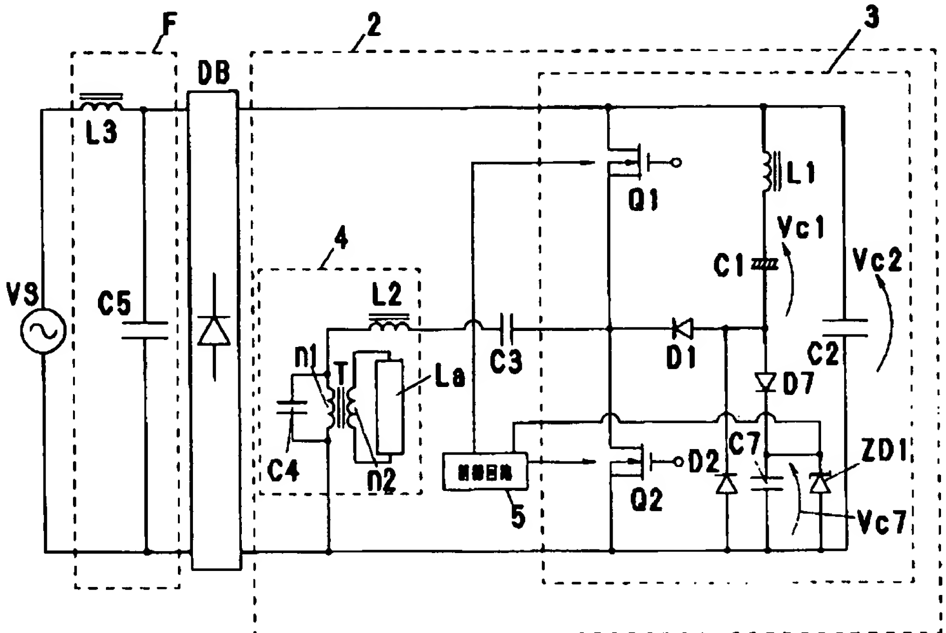
【Figure 1 5】



【Figure 1 6】



【Figure 17】



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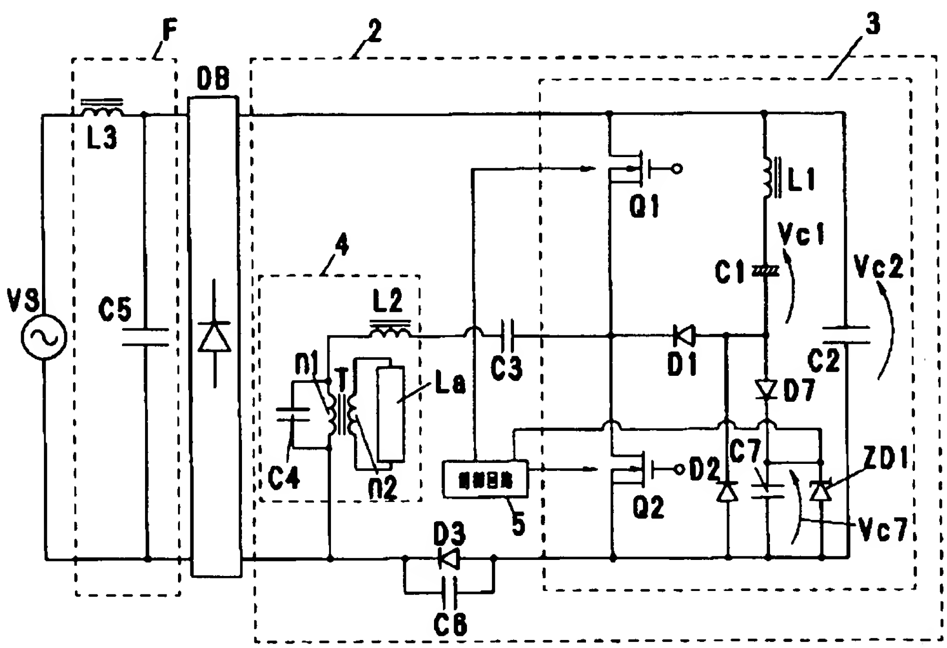
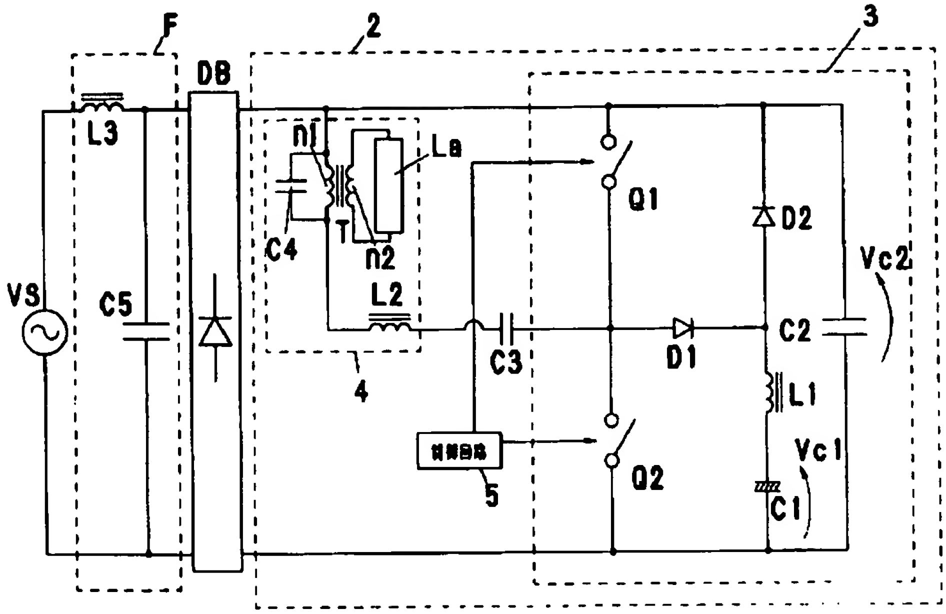
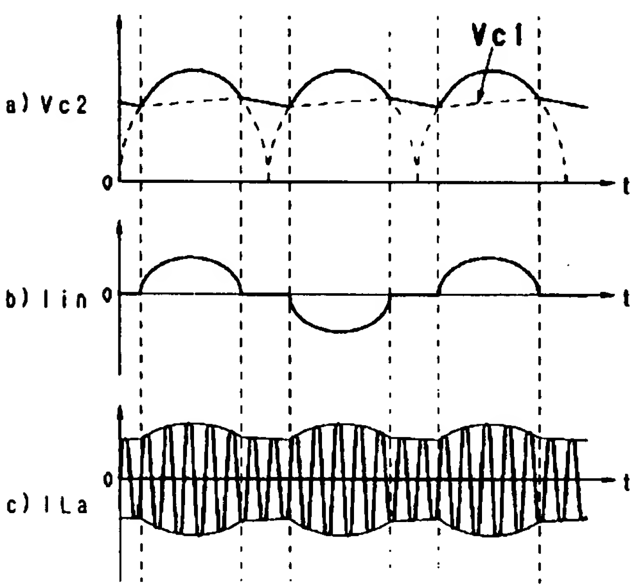


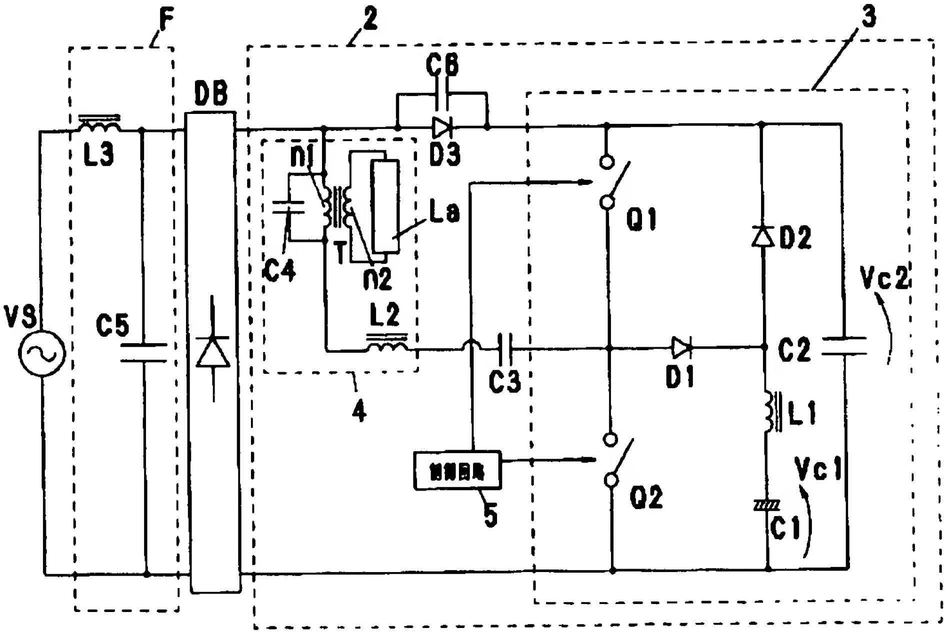
【Figure 1 9】



【Figure 2 0】



【Figure 2 1】



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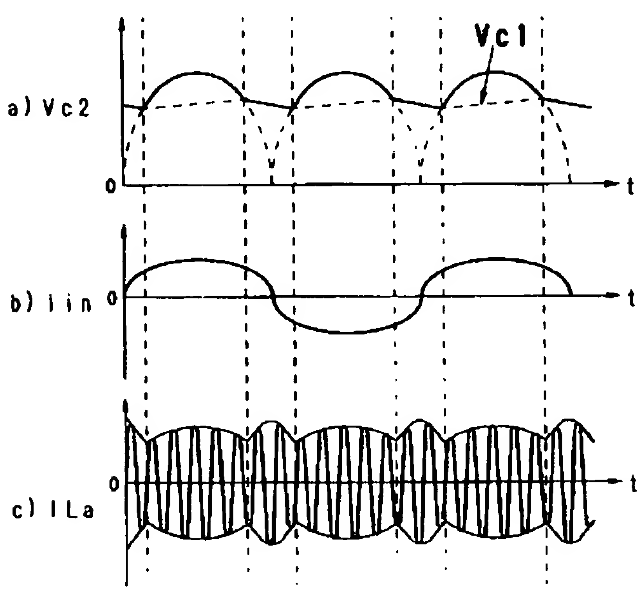

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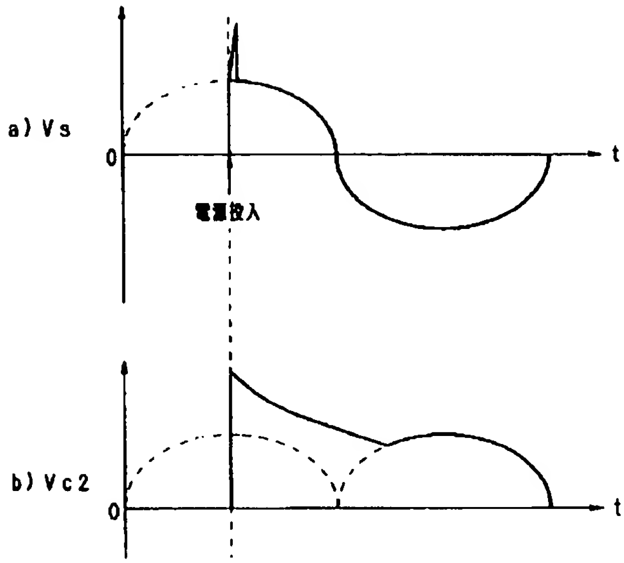
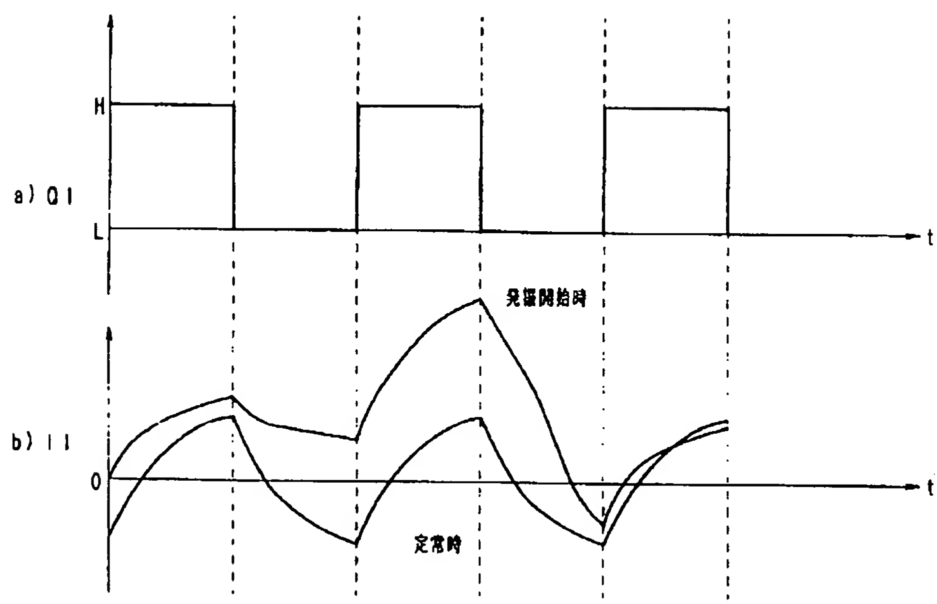
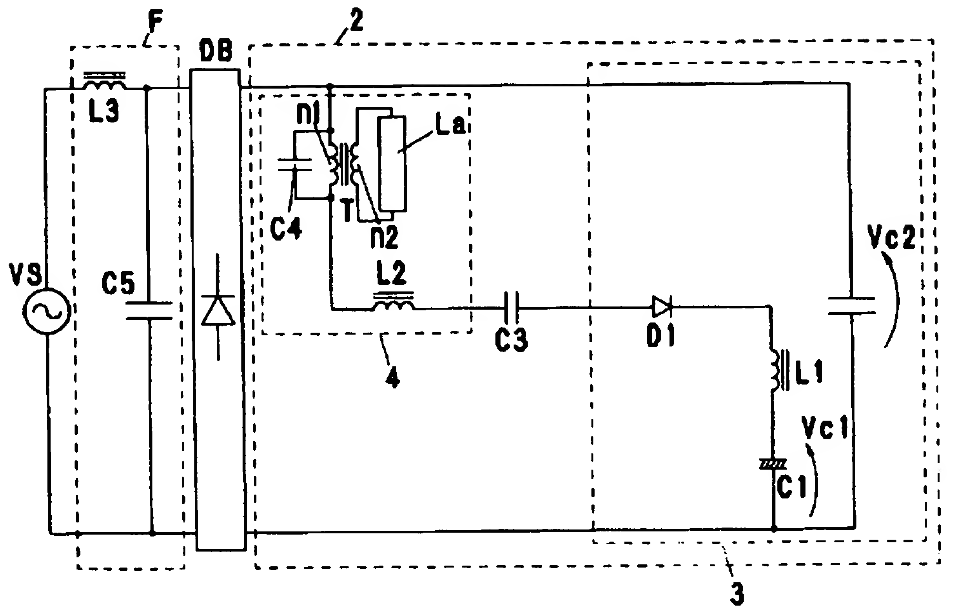


【Figure 2 4】



【Figure 2 5】



【Figure 2 6】